

### **REMARKS**

Claims 1 - 20 were pending in this application.

Claims 1, 2 and 4-20 were allowed.

Claims 3 was amended

### **L 35 USC 112 Rejections**

The Examiner has objected to the wording of Claim 3 under 35 USC 112, second paragraph. Claim 3 has been amended to remove the cause of rejection. All pending claims are now believed to stand in proper form under 35 USC 112.

### **11. SUMMARY**

Having responded to all of the Examiner's objections, this application is believed to stand in condition for allowance. However, if the Examiner is of the opinion that such action cannot be taken, the Examiner is requested to call the applicant's attorney at (215) 321-6772 in order that any outstanding issues may be resolved without the necessity of issuing a further Office Action.

Respectfully Submitted,



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through that wall in a given period of time. As such, in order to make the conduit more efficient, a thinner wall is desirable. However, as has already been stated, a conduit wall cannot be made  
5 so thin that it ruptures or collapses under the pressure of the gases being passed through that conduit.

To further complicate matters, conduits made from palladium and palladium alloys may become less  
10 efficient over time as the interior walls of the conduits become clogged with contaminants. In order to elongate the life of such conduits, many manufacturers attempt to clean the conduits by reverse pressurizing the conduits. In such a  
15 procedure, the exterior of the conduit is exposed to pressurized hydrogen. The hydrogen passes through the conduit wall and into the interior of the conduit. As the hydrogen passes into the interior of the conduit, the hydrogen may remove  
20 some of the contaminants that were deposited on the interior wall of the conduit.

membrane from rupturing, solid perforated  
substrates are used to reinforce the membrane. The  
solid perforated substrates, however, are  
complicated to manufacture, restrict the flow  
5 through the membrane, and reduce the efficiency of  
the overall system.

U.S. Patent No. 6,152,987 to Ma, entitled  
Hydrogen Gas-Extraction Module And Method Of  
Fabrication, discloses a hydrogen separator where a  
10 solid layer of hydrogen permeable material is  
deposited over a porous substrate of dissimilar  
material. The porous substrate supports the  
hydrogen permeable material and provides much more  
support than prior art mesh support systems.

15 However, the porous substrate only allows gas to  
contact the hydrogen permeable material where a  
pore gap is exposed to the hydrogen permeable  
material. This configuration greatly limits the  
area of hydrogen permeable material actually  
20 exposed to gas. Furthermore, due to differences in  
thermal coefficients and other physical properties,

hydrogen permeable material deposited on a  
substrate of a dissimilar material tends to  
separate from the substrate. This can cause leakage  
of contaminated gas through the hydrogen permeable  
material and the eventual failure of the system.

U.S. Patent Application No. 2003/0190486 to  
Roa et al, also discloses a hydrogen separator  
where a solid layer of hydrogen permeable material  
is deposited over a porous substrate of dissimilar  
material. In the Roa application, a palladium alloy  
is deposited over the porous substrate of  
dissimilar material using a first electroplating  
process. Copper is then deposited on the palladium  
in a second electroplating process. The palladium  
and copper layers are then annealed to produce a  
palladium alloy in place on the substrate. However,  
the porous substrate only allows gas to contact the  
hydrogen permeable material where a pore gap is  
exposed to the hydrogen permeable material. This  
configuration greatly limits the area of hydrogen  
permeable material actually exposed to gas.

32 until it contacts the deposited solid layer 34.

The deposited solid layer 34 blocks all gases except hydrogen. The hydrogen permeates through the solid layer 34 where the hydrogen gas directly  
5 contacts the solid layer 34. However, the hydrogen gas can also permeate into the areas of the first porous hydrogen permeable layer 32 that are contacting and supporting the deposited solid layer 34. As a result, a very large surface area is  
10 available through which hydrogen gas can pass.

Once the hydrogen gas permeates across the deposited solid layer 34, it enters the second porous hydrogen permeable layer 36. The second porous hydrogen permeable layer 36 provides very  
15 little resistance to the further passage of the now purified hydrogen gas into the surrounding collection chamber 12.

When the composite hydrogen separator 20 is being cleaned, pressure differentials are reversed.  
20 The second porous hydrogen permeable layer 36 then acts to increase the effective surface area of the

deposited solid layer 34 as hydrogen gas flows into the composite hydrogen separator 20 toward the central conduit 22.

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EXAMPLE OF A MICROSTRUCTURE COMPOSITION FOR A  
HYDROGEN SEPARATION MEMBRANE

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As has been previously mentioned, various layers of the wall 24 of the composite hydrogen separator 20 can be made in different ways.

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Referring to Fig. 3, it will be understood that the base layer 30 is preferably a sintered metal that is sintered into a porous form having a pore ~~pore~~ size of approximately 0.5  $\mu\text{m}$  to 0.9  $\mu\text{m}$ . An average pore size of 0.7  $\mu\text{m}$  being preferred and used by way of example. Because of the overall process flexibility and geometric scaling, there is a considerable variation in possible average pore diameter. The base layer 30 can be sintered in the desired form 41 or a sintered block can be machined into the desired base form 41. In the shown

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proportional to the original thickness stated above  
for the case of pore size in base layer 30 of 0.7  
microns.

It will be understood that the materials  
described for the bonding layers 33, 35, 37 are  
exemplary and can be changed. For instance, the  
first two bonding layers 33, 35 can be made from  
material that is not hydrogen permeable. The third  
bonding layer 37 can be made permeable to hydrogen  
and alloy-forming with subsequent layers for  
diffusion bonding

Referring to Fig. 5, it can be seen that the  
first porous hydrogen permeable layer 32 is  
deposited over the bonding layers 33, 35, 37. This  
can be accomplished in a variety of ways. In the  
shown manufacturing method, particles of palladium  
and copper are suspended in a rheological vehicle,  
such as Hereaus-Cermalloy V633 or V636. Such  
rheological vehicles are thixotropic agents which  
are commonly used in nitrogen fireable thick film  
paste formulations. This suspension forms a thick

permeable material 84 is applied to the bonding layers 83 using tradition deposition techniques. The first layer of hydrogen permeable material 84 is then perforated by chemical etching or laser etching. The size of the perforations in the base substrate 82 and the size of the perforations in the first layer of hydrogen permeable material 84 are preferably made to be comparable to maintain a constant porosity throughout the two layers.

A second layer of hydrogen permeable material 86 is then deposited over the first layer of hydrogen permeable material 84. The second layer of hydrogen permeable material 86 can be partially etched to increase the surface area exposed on its top. However, the etching of the second layer of hydrogen permeable material 86 is only partial and the second later of hydrogen permeable material 86 remains as a solid barrier over the first porous layer of hydrogen permeable material 84.

It will be understood that the embodiments of the present invention system and method that are